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## THE OIL- AND GAS-PRODUCING ROCKS OF OHIO.<sup>1</sup>

THIS state began producing oil in 1860. From that period until 1885 the output was restricted to the eastern part of the state, and was derived entirely from rocks of Carboniferous age. The production during that time was relatively small, and of little importance in a commercial sense. In 1885 the vast repository in the Trenton limestone was discovered, and this at once gave the industry in the state great impetus. The yield was such that in 1895 it surpassed that of Pennsylvania and New York combined, and since that date the state has held the first rank. Gas first became an important fuel in Ohio in 1884, the year of the great discovery at Findlay. From 1888 to 1900, inclusive, the value of this product exceeded \$28,000,000.

The rocks, particularly the lower ones, producing these vast supplies have been in part studied, especially by Orton,<sup>2</sup> but thus far no paper has been published which considered all the producing strata. It is the purpose of this article to enumerate these, to discuss briefly their composition and general characters, and to show their stratigraphical position.

### THE ORDOVICIAN.

In Ohio the upper half only of this great division needs be considered. This is divided by Orton as follows:

- |                        |   |   |   |              |
|------------------------|---|---|---|--------------|
| 3. Hudson River series | - | - | - | 300-750 feet |
| 2. Utica shales        | - | - | - | 0-300        |
| 1. Trenton limestone   | - | - | - | 50           |

The upper two members contain both oil and gas, but rarely in commercial quantities. Occasionally high-pressure gas wells are found, but these soon give out. Nowhere in Ohio can either of these formations be regarded as a producer of natural gas. Occasionally in the northwestern corner of the state oil is found

<sup>1</sup> Published by permission of Edward Orton, Jr., state geologist.

<sup>2</sup> *Geological Survey of Ohio*, Vol. VI, and *First Annual Report* (1890).



gas-bearing beds are magnesian. This is shown by the following analyses:

	CaCO <sub>3</sub>	MgCO <sub>3</sub>	Ins. Res.	Al and FeOx.
Findlay gas rock.....	53.50	43.05	1.70	1.25
Bowling Green gas rock....	51.78	36.80	4.89	....
Lima oil rock.....	55.90	38.85	.75	2.94

It was further found that in some places at least the magnesian character of the rock changes rapidly from the surface of the formation down. Thus an analysis of the rock lying 100 feet below the top of the Trenton at Bowling Green showed over 88 per cent. of CaCO<sub>3</sub> and less than 7 per cent. of MgCO<sub>3</sub>; while, as shown above, the upper portion of the same formation has less than 52 per cent. of CaCO<sub>3</sub> and more than 36 per cent. of MgCO<sub>3</sub>. The magnesian character is important, since it renders the rock porous, thus making it a suitable reservoir for the oil and gas. Outside of the producing territory in Ohio the Trenton loses its magnesian character, the CaCO<sub>3</sub> composing usually at least 75 per cent. of the formation.<sup>1</sup>

The rock is often highly fossiliferous, and occasionally the pieces brought up by the sand pump are little more than a cemented mass of shells, resembling in this respect the limestones of the Hudson River series. Dr. Orton referred the formation, as shown in the Findlay well, to the Galena, Trenton proper, and Birdseye divisions.<sup>2</sup> The total thickness of the Trenton in northwestern Ohio is unknown, but it exceeds 780 feet. In the southwestern part of the state it is 650 feet, as shown in a well drilled on the McGhee farm in Liberty township, Adams county. This thickness is similar to that reported in Kentucky.

The relation stratigraphically of the Trenton to the next important producer, the Clinton, is shown in the following records:

<sup>1</sup> *Ibid.*, Vol. VI, pp. 103, 104.

<sup>2</sup> *Ibid.*, Vol. VI, p. 116.

## WELL NO. 1, HAINES FARM, ROSEVILLE, SANDUSKY COUNTY

Drive pipe	-	-	-	-	-	-	30 feet
Niagara series,	{	Gray lime	-	-	-	-	140
		White lime	-	-	-	-	160
		Blue lime	-	-	-	-	20
		White slate, first break	-	-	-	-	2
		Brown lime, hard	-	-	-	-	21
		Light slate, second break	-	-	-	-	20
Clinton limestone	-	-	-	-	-	-	100
Medina shales (red)	-	-	-	-	-	-	80
Hudson River series (white shales)	-	-	-	-	-	-	427
Utica shale (brown)	-	-	-	-	-	-	252 ½
Trenton limestone at	-	-	-	-	-	-	1,252 ½

For comparison a record is given of a well drilled on the Rohr farm near Groveport, Franklin county, in the central part of the state :

Drift	-	-	-	-	-	-	136 feet
Ohio shales	-	-	-	-	-	-	167
Corniferous limestone, top at	-	-	-	-	-	-	303
Niagara limestone, bottom at	-	-	-	-	-	-	980
Clinton shales	-	-	-	-	-	-	110
Clinton sand, shells only at	-	-	-	-	-	-	1,110
Trenton limestone at	-	-	-	-	-	-	2,146
Bottom of well (in Trenton)	-	-	-	-	-	-	2,675

## THE SILURIAN.

The rocks of this age in Ohio are divided by Orton as follows:<sup>1</sup>

- |                                |   |   |             |
|--------------------------------|---|---|-------------|
| 4. Lower Helderberg limestone  | - | - | 50-600 feet |
| 3. Niagara limestone and shale | - | - | 125-380     |
| 2. Clinton group               | - | - | 20-150      |
| 1. Medina shale                | - | - | 25-150      |

*The Clinton.*—Of these divisions the second and fourth only call for recognition in this article. Along its line of outcrop in southwestern Ohio the Clinton consists essentially of a highly crystalline limestone, rich in fossils, especially crinoid stems. Commonly it has a light color, the tint of which varies from place to place. The rock takes a good polish, and is sometimes called marble. Occasionally the formation contains lean hematite, and

<sup>1</sup> *Ibid.*, Vol. VII, pp. 4, 5.

one of the earliest blast furnaces in the state relied on this ore. In composition the rock is calcareous, and at one point becomes the purest rock of this type in the state.

Northward, under cover, the rock undergoes notable changes, the result being that it closely resembles the overlying Niagara. It is in the central portion of the state, however, that the greatest change is found. Instead of a well-marked limestone, there is found in its place shales of different colors and composition and a conspicuous sandstone; the latter the repository for the great reservoirs of gas in Fairfield, Hocking, Licking and Knox counties. In northern Vinton county a pool of oil also has lately been found in it, and one well has been secured in Perry county.

The relations of these beds to the overlying Niagara are shown in the following partial log of a well on the Bauer farm near Sugar Grove. Samples of drillings below the Niagara were taken by the writer.

Berea grit	- - - - -	{ top at 620 feet bottom at 645
Corniferous, Helderberg, and Niagara limestones	- - -	{ top at 1,430 bottom at 2,132
Clinton	{ Shales, light chocolate-colored.	{ top at 2,132
	{ Little lime - - - - -	{ bottom at 2,168
	{ Shales, green and chocolate-colored,	{ top at 2,168
	{ the latter fossiliferous. Some lime	{ bottom at 2,199
	{ Shales, green and chocolate-colored.	{ top at 2,199
	{ Much lime - - - - -	{ bottom at 2,236
	{ Clinton sand at - - - - -	2,236

Generally when the gas sand has been penetrated to a depth of from 10 to 15 feet the drill is stopped, and consequently data farther down are less abundant. In western Ohio the basal portion of the Niagara is commonly occupied by shales,<sup>1</sup> but northward and eastward this member contracts. In central Ohio it consists of shales and thin beds of limestone, and the bottom of these is regarded as the line of junction of the Niagara and the Clinton.

The following skeleton record of a well on the Spire farm near Sugar Grove shows the position of the Medina as well as the Clinton:

<sup>1</sup> *Ibid.*, pp. 11-13.

Drift	-	-	-	-	-	-	-	-	11 feet
Berea grit, bottom at	-	-	-	-	-	-	-	-	460
Corniferous, Helderberg, and Niagara limestones,									
top at	-	-	-	-	-	-	-	-	1,235
bottom at	-	-	-	-	-	-	-	-	1,921
Clinton sand, top at	-	-	-	-	-	-	-	-	2,025
bottom at	-	-	-	-	-	-	-	-	2,045
Medina (red shales) top at	-	-	-	-	-	-	-	-	2,055
Bottom of well at	-	-	-	-	-	-	-	-	2,075

This makes the red shales lying from 10 to 30 feet below the Clinton sand, the top of the Medina.

*The Lower Helderberg.*—Rocks of this age produce gas and oil in one locality, viz., near Jefferson, Ashtabula county. The succession of strata there is shown by the following record of Webb Well No. 1. All measurements were made with a steel line.

	Thickness of formation.	Total depth.
Drift	33 feet.	33 feet.
Ohio shales	1,671	1,704
Corniferous and Lower Helderberg limestones	288	1,992
Gas sand at	-	1,992

The sand, which is from 30 to 40 feet in thickness, is interbedded in the Lower Helderberg limestone. Similar conditions are found in Lucas and Wood counties, in the former of which the sand has been quarried for the manufacture of glass.<sup>1</sup> In the gas field under consideration the sand is moderately coarse, has a light color, and is highly fossiliferous. The gas is found in the top of the formation, and just below lies a large and threatening reservoir of salt water. A number of towns and villages are being supplied with fuel from this field. The oil wells are few in number and insignificant in production.

#### THE DEVONIAN.

The rocks of this age found in Ohio, have been classified by Orton<sup>2</sup> as follows:

3. Ohio shales	-	-	-	-	-	250-3,000 feet
2. Olentangy shale	-	-	-	-	-	25
3. Devonian limestone (Corniferous)						75

<sup>1</sup> *Ibid.*, p. 17.

<sup>2</sup> *Ibid.*, pp. 4 and 18-26.

None of these formations produce oil, and the Ohio shales alone yield gas. The available supply of this, however is very small, and its use has been limited to domestic purposes. The principal counties have been those along the lake shore in the northeastern corner of the state. These shales, which underlie the eastern half of the state, are wedge-shaped, with the apex reaching from the lake to the Ohio. The cities, Columbus, Delaware, and Bucyrus, lie on or near this apex. Eastward the formation thickens rapidly and near Wellsville on the Ohio river has been penetrated to a depth of 2,600 feet without reaching the base. This feature has led to much confusion on the part of the driller, who has expected to find the interval between the Berea grit and the Devonian limestone, the same in the eastern part of the state that he did in the central.

The gas secured in these shales is not from any one horizon, but varies stratigraphically from place to place. The wells are all small. Very commonly the shales make a show of gas, but usually the yield is so light as to be commercially valueless. The aggregate amount contained, however, must be very large, and if it could be collected would form one of the most valuable supplies of fuel in the state.<sup>1</sup>

#### THE CARBONIFEROUS.

Classifying the formations of this great division, as has been customary, into the Lower Carboniferous, Coal-measures, and Permian, it is found that the oil- and gas-bearing rocks are restricted to the first two members. These will now be considered in order.

##### I. THE LOWER CARBONIFEROUS.

*The Berea grit.*—This is the most extensive sandstone of the state. Its area above and below drainage is about 15,000 square miles, or more than one-third of the area of the state. Its value is commensurate with its extent. "Its economic value above ground is great, but it is greater below. In its outcrop it is a source of the finest building-stone and the best grindstone grit

<sup>1</sup> For a full discussion of this subject see *Geological Survey of Ohio*, Vol. VI. pp. 410-42.



of the country, and when it dips beneath the surface it becomes the repository of invaluable supplies of petroleum, gas, and salt water."<sup>1</sup>

The composition and structure are very constant. The color is gray below drainage, but has a tinge of yellow above. The sand is of moderate fineness, and composed almost wholly of silica. Occasionally it contains carbonate of lime, probably as a cement, but this never constitutes more than a very small fraction of the formation. That found below the surface around the village Berea in Cuyahoga county is undistinguishable from that obtained at a depth of more than 2,000 feet in Washington county. Sometimes, though not usually, the formation divides, a bed of shale lying between two of sandstone; at other places the upper portion of the formation consists of sandstone and the lower of shales. In thickness the formation varies from 50 feet or more in the northern part of the state to a half dozen or less in the southeastern portion, and occasionally disappears entirely, its place being occupied by shales. The Berea grit is succeeded above by the Berea (Sunbury) and Cuyahoga shales, having usually an aggregate thickness of from 500 to 600 feet, and below by the Ohio shales, having a great and rapidly increasing thickness eastward. The most remarkable character of the formation, however, remains to be mentioned, viz., its persistence. From its outcrop it has been followed by the drill from county to county, and often from section to section, until the eastern and southeastern limit of the state is reached. It is as easily recognized below drainage as above, and this character makes it a stratigraphical landmark of great value to both driller and geologist. In many counties in the eastern part of the state, especially those fronting on the river, numerous efforts have been made to find a productive sand below the Berea, but in every case this effort has been unsuccessful. It may now be taken as having been demonstrated by the drill that when the Berea sand has been passed in this territory the last hope of oil or gas has gone.

While a trace of oil or gas has perhaps been found in every

<sup>1</sup> *Ibid.*, Vol. VII, p. 28.

county where the formation exists, the production in commercial quantities is limited to Lorain, Medina, Trumbull, Columbiana, Stark, Jefferson, Harrison, Belmont, Guernsey, Monroe, Noble, Vinton, Perry, Athens, Morgan, and Washington counties.

*The Logan group.*—The relative position of this group and the Berea is shown by the following skeleton record of a well on the Mead farm in the Elk Run Pool, Washington county.

Logan group	{	Salt sand - - - -	{	top at	1,200 feet.
			{	bottom at	1,280
	{	Maxton sand - - -	{	top at	1,450
			{	bottom at	1,500
	{	Mountain limestone	{	top at	1,510
		("Big lime") - -	{	bottom at	1,545
	{	Big Injun series - -	{	top at	1,560
			{	bottom at	1,730
Berea grit	{	- - - - -	{	top at	2,124
			{	bottom at	2,138

This shows that the two formations are about 400 feet apart, and as has already been stated the interval is occupied by the Berea and Cuyahoga shales.

The Logan group, as classified by Orton, consists of three members—a conglomerate, sandstone, and shale—and has a maximum thickness of 350 feet.<sup>1</sup> Quite recently, however, Professor Prosser has considered the question, and he divides the group as follows:<sup>2</sup>

2. Logan formation = Logan sandstone and shales.

1. Black Hand Formation = Logan conglomerate.

Recent work by the drill demonstrates that the maximum thickness is twice that stated by Orton. The group is limited above by the Lower Carboniferous limestone, but this is rarely recognized in deep wells, and consequently the upper limit is usually uncertain. The first member of the group that is recognized by the driller is the Salt sand. The relation stratigraphically of this member to the Lower Carboniferous limestone is shown by the following record of a well on the Longshore farm in section 15 of Brush Creek township, Muskingum county. All measurements were made with a steel line.

<sup>1</sup> *Ibid.*, Vol. VII, pp. 4, 5, 32-5.

<sup>2</sup> *JOUR. GEOL.*, Vol. IX, pp. 205-31.

Putnam Hill limestone	-	{	top at	20 feet.
		}	bottom at	23
Lower Carboniferous limestone		{	top at	225
		}	bottom at	265
Salt sand	- - -	{	top at	450
		}	bottom at	485
Berea shale	- - -	{	top at	919
		}	bottom at	952
Berea grit	- - -	{	top at	950
		}	bottom at	980
Bedford shales (brick red)	-	{	top at	980
		}	bottom at	1,010
Ohio shales, top at	- - - - -			1,010

This shows that the Salt sand lies 185 feet below the Lower Carboniferous limestone. Combining this with the record of the Mead well previously given makes a total thickness for the Logan group of 715 feet. Probably in the extreme southeastern corner of the state the thickness is still greater.

Above drainage the group is well marked. Hills capped with sandstone or conglomerate stand out in bold relief, so that the limits of the formation are discernible from a distance. The conglomerate is the most conspicuous member of the group. It is essentially a quartz rock, the largest pebbles of which do not commonly exceed one-half of an inch in diameter. It is the best known bridge stone in the state. The sandstone member has usually a yellow or brown color, but sometimes this becomes strikingly variegated. It is extensively used for building purposes. The members of this group are much less constant in their physical characters than the Berea grit, and hence their identification is correspondingly more difficult.

Under cover the Logan group undergoes important changes, and the several formations are given different names from those at the surface. Thus, instead of the Logan conglomerate, sandstone, and shale, we have the Big Injun sand, Mountain limestone, Salt sand, etc. The correlation of the strata bearing these two sets of names is as follows. This is based on their stratigraphical succession and lithology. While the limits underground cannot be sharply drawn in most cases, they are perhaps as definite as those along the line of outcrop.

Logan shales	=shales (unnamed)
Logan sandstone	=Salt sand
Logan conglomerate	} = Mountain limestone Big Injun series

The limestone just named, and which is known also as the "Big lime," has a maximum thickness in this state of 110 feet. It is a light-colored, hard, massive rock, free from oil and gas except along its margin, where the formation becomes broken and the layers of limestone are intercalated with sandstone. The formation is wedge-shaped with the apex to the northwest. It is limited to the eastern half of Washington and Monroe counties, and the southeastern corner of Belmont. To the west and north its place is occupied by shales and sandstones. The formation divides the Logan group into two unequal parts, and serves as a guide-post to the driller.

*The Big Injun series.*—This consists of the following members :

Slate	-	-	0- 20 feet
<i>Keener sand</i>	-	-	0- 60
Slate	-	-	0- 25
<i>Big Injun sand</i>			0-175
Slate	-	-	0- 10
<i>Squaw sand</i>	-		0- 30

From this it is seen that the group varies greatly. Sometimes it is little more than one great mass of sandstone, while at other times it is broken into a series of alternating beds of slate and sandstone. The Keener sand occasionally lies immediately below the Mountain limestone, but more often is separated from that rock by a few feet of shales. It varies considerably in texture, but is usually coarse and open, sometimes conglomeritic. The sand was named from the Keener farm near Sistersville, West Virginia.<sup>1</sup> It is an important source of oil in Monroe and Washington counties. The sand is separated from the underlying Big Injun by a bed of slate. Sometimes the latter is wanting, and then the two sands run together and are conjointly called the Big Injun. The sand in question (Big Injun) is by far the thickest member of the series, but in other respects

<sup>1</sup> *West Virginia Geological Survey*, Vol. I, p. 357.

resembles the Keener. It is recognized in several counties in southeastern Ohio, but is a producer of oil or gas in commercial quantities in Monroe and Washington counties only. To the west and north the formation becomes too broken to be a repository for oil or gas. Below the Big Injun, and separated from it by a thin bed of shales, there is occasionally found another layer of sand known as the Squaw. It is decidedly patchy and never extends over large areas in this state. The best records of it are reported from Monroe county, but it is of little importance even there.

*The Salt sand.*—This is the highest of the sands of the Logan group. It has a gray color, is moderately coarse, and nearly always is charged with brine. Occasionally it contains a little oil and gas, but it cannot be recognized as a producer of either.

## II. THE COAL-MEASURES.

While a large number of strata belonging to the Coal-measures have been or are now sources of oil, comparatively few of these have been important in a commercial sense. Generally the sands are local, and cannot be traced over an area of more than a fraction of a mile. Such sands usually have names, but because of their small area and production they will not be further noticed in this article. The most important sands of the Coal-measures are the following:

5. Goose Run sand.
4. Mitchell sand.
3. First Cow Run sand.
2. Macksburg 500-foot sand.
1. Second Cow Run sand.

The relative positions of sands 1 and 3 are shown by the following data taken from Centennial Well No. 6 at Cow Run:

	Thickness	Depth to top of formation
Pittsburg coal - - - -	1 foot	11 feet
First Cow Run sand - - -	47 feet	325
Second Cow Run sand - -	64	776

The stratigraphical relation of sands 2 and 3 is shown by the following record taken from Dunn Well No. 6, near Macksburg. The well head is six feet below the Meigs Creek coal.

	Thickness.	Depth to top of formation.
Ames limestone, - - -	1 foot	285 feet
First Cow Run sand - - -	5 feet	385
Cambridge limestone - - -	4	411
Dunkard sand (300-foot) - - -	95	530
Macksburg 500-foot sand - - -	22	702

The Dunkard or 300-foot sand is quite generally regarded as the equivalent of the Mahoning. That this cannot be correct is shown by the following partial section of the Hocking Valley coal field.<sup>1</sup>

	Thickness.
Cambridge limestone - - -	2-10 feet
Mahoning sandstone, upper division, -	50
Brush Creek coal (No. 7a) - - -	2 ½
Brush Creek limestone - - -	4
Mahoning sandstone, lower division -	15-25
Upper Freeport coal - - -	0-3
Upper Freeport { Clay { Shales - - - { Limestone and sandstone	35
Middle Kittaning coal (No. 6) - - -	5-13

This shows the Mahoning sandstone lying immediately below the Cambridge lime, but experience in the field demonstrates that the two are not ordinarily in contact. Measuring from the base of the lime rock to that of the Mahoning, an interval of 76 feet is found, while, according to the records in the Dunn well, the interval is 210 feet. A divergence of this sort cannot be explained by assuming that the section expands eastward, for a study of the relative positions of the Pittsburgh coal, the Ames and Cambridge limestones farther west with the same formations near Macksburg, shows no material change, and it is certainly unreasonable to assume that the formations just below the Cambridge limestone expand at anything like the rate that would be necessary to make the interval which this nomenclature requires. Further, naming the sand in question the Mahoning makes impossible a rational classification of the lower formations. The position of the sand with reference to the Cambridge lime is that of the Upper Freeport.

<sup>1</sup> *Geological Survey of Ohio*, Vol. V, p. 918.

The positions of sands 3 and 4 are shown by the record of Centennial Well No. 7, at Cow Run. The well head is at the horizon of the Meigs Creek coal.

	Thickness.	Depth to top of formation.
Pittsburg coal (No. 8) - - -	1	116 feet
Mitchell sand - - -	25	205
Red shales ("Big Red") - -	80	235
First Cow Run sand - - -	32	423

The relative positions of sands 4 and 5 are shown by the following taken from Reed Well No. 4, near Marietta :

Goose Run sand -	{ top at 300 feet bottom at 331
Mitchell sand - - -	{ top at 525 bottom at 546

*The Second Cow Run sand.*—This is one of the least important members of the group now under consideration. It has been a small producer at Cow Run in Washington county for more than thirty years, but rarely has been found beyond that locality. It is reported, however, quite frequently, for the driller gives this name to almost any sand lying from 100 to 500 feet below the first Cow Run sand. As may be seen from the records given the interval between the two is 400 feet. It lies 760 feet below the Pittsburg coal, and is the thickest member of the group, sometimes exceeding 60 feet. Occasionally the formation is divided by few feet of slate, in which case the oil lies in the lower part. The sand possesses no qualities that serve to distinguish it from the higher members.

The sand belongs near the base of the Coal-measures. The partial record of the Rice well, given below, shows it to be the first sand above the Salt sand, the two being separated by 79 feet of shales, the latter probably the equivalent of the shales of the Logan group. This, with the thickness of the formation, and the fact that it is sometimes divided by a few feet of shales, makes quite certain its identification as the Massillon sandstone.

*The Macksburg 500-foot sand.*—This is important at Macksburg and vicinity only. It lies 670 feet below the Meigs Creek coal

and about 580 feet below the Pittsburg, as is shown in the following partial log of George Rice Well No. 18, at Macksburg.<sup>1</sup>

	Thickness.	To top of formation.
Meigs Creek coal - - -	5 feet	10 feet
First Cow Run sand - - -	35	343
Dunkard sand (300-foot) - - -	78	554
500-foot sand - - -	17	685
Sand, pebbly (800-foot) - - -	51	775
Slate - - - - -	79	826
Salt sand - - - - -	190	905

This sand commonly ranges from 10 to 30 feet in thickness. It is usually quite coarse, but does not become a conglomerate. Like the First Cow Run sand, it does not form a continuous stratum, but is decidedly patchy. Stratigraphically considered, the formation belongs near the top of the Conglomerate Coal-measures, and its position with reference to the Cambridge lime and Dunkard sand strongly indicates that it is the Tionesta sandstone.

The Second Cow Run and the Macksburg 500-foot sand have been regarded by many as equivalent. As has already been suggested by Professor White, however, this cannot be the case.<sup>2</sup> Examination of the record of the Rice well shows that the interval between the First Cow Run and 500-foot sands is only 307 feet, while, as already stated, the interval should be 400 feet. Measuring from the Meigs Creek coal, equally conclusive figures are secured. Thus the Second Cow Run sand lies 840 feet below the Meigs Creek coal, while the interval between this seam and the 500-foot sand is only 670 feet. The sand at Macksburg known as the 800-foot is probably the equivalent of the Second Cow Run.

*The First Cow Run sand.*—This is the most important and best-known sand of the group. As is shown in the record of the Dunn well, its position is 100 feet below the Ames limestone. In western Morgan county, near the outcrop of the sand, the interval ranges from 70 feet to 100. The Ames limestone there lies 170 feet below the Pittsburg coal. The identification of the

<sup>1</sup>*West Virginia Geol. Sur.*, Vol. I, p. 298.

<sup>2</sup>*West Virginia Geological Survey*, Vol. I, p. 299.



sand is made more certain by the fact that the Cambridge limestone lies immediately below or is separated from the sand by a thin bed of shales. Unfortunately these limestones are not recognized in Monroe and the eastern part of Washington counties, and hence the sand in question often cannot be identified there with certainty. In such localities any shallow sand, especially if it makes a show of oil or gas, is known as the Cow Run. The relation of the sand to the two limestones places it about 100 feet above the base of the Conemaugh formation.

If the Berea grit be taken as the type of a persistent stratum of sandstone, the First Cow Run sand may properly be selected as the representative of the opposite type. It is the most patchy of the oil or gas rocks of Ohio. The maximum thickness of the formation may be taken at 50 feet, but even a short distance from this the stratum may become very thin or actually disappear entirely. The texture varies much, and where productive is sometimes conglomeritic. Pebbles three-fourths of an inch in diameter have been found, and those one-fourth of an inch are common. The pebbles consist of quartz, but small grains of other minerals are found. From this type the formation changes to a hard compact sandstone.

The sand is an important source of oil in Morgan and Washington counties. It seems to have been first struck at Macksburg in 1860, where it is known as the 140-foot sand; this being the depth at which the sand was found in the valley at that place. In 1861 the sand was found at Cow Run and has there been a producer ever since. It is seen that the latter name has not the claim of priority, but it is so much more widely used that it is here retained.

*The Mitchell sand.*—This is the source of a small oil field a few miles east of Marietta. The sand is comparable in thickness with the First Cow Run, but in texture is less conglomeritic. As has been shown, it lies about 90 feet below the Pittsburgh coal, or 200 feet above the First Cow Run sand. Its place is near the summit of the Conemaugh formation. Wells in this sand commonly begin with a relatively large production, but decrease very rapidly.

*The Goose Run sand.*—The formation known by this name has supplied a score or more small wells near Marietta. The sand is patchy, and the life of the wells very short. In fact, the rock is of little value, and is recognized here simply to make the record complete stratigraphically. Lying nearly 200 feet above the Mitchell, the sand belongs 100 feet above the Pittsburg coal, or, in other words, near the middle of the Monongahela formation.

The following table shows the great divisions of the Coal-measures of Ohio, and also the approximate positions, at least, in these of the several sands just discussed:

Dunkard formation, or Upper Barren Coal-measures, 500 feet.	{	No oil or gas rocks.
Monongahela Formation, or Upper Productive Coal-measures, 200 feet.	{	Goose Run Sand. 100 feet. Pittsburg or No. 8 coal. 90 feet. Mitchell sand. 200 feet.
Conemaugh formation, or Lower Barren Coal-measures, 500 feet.	{	First Cow Run sand. Cambridge limestone. Mahoning sandstone. Upper Freeport or No. 7 coal. Dunkard or 300-foot sand = ? Freeport sandstone. 50 feet.
Allegheny Formation, or Lower Productive Coal-measures, 250 feet.	{	Macksburg 500-foot sand = ? Tionesta sandstone. 70 feet. Second Cow Run sand = Massillon sandstone. Sharon or No. 1 Coal.
Conglomerate Coal-measures, 250 feet.	{	

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